UNIVERSITI PUTRA MALAYSIA

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By

TRI HESTI WAHYUNI

Thesis Submitted in Fulfilment of the Requirements for the Degree of Master of Science in the Faculty of Agriculture Universiti Putra Malaysia

September 2000

DEDICATION

Dedicated especially to my beloved husband, Ahmad Armijn Nasution, SH whose sacrifice and support has enabled me to complete this study successfully and to my lovely daughters and son, Windha Arresti Hartanty, Thia Ayu Armindasari and Ahmad Gunawan Muttaqien, whom I love most.

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Agriculture

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Chairman: Associate Professor Abdul Razak Alimon, Ph.D.

Faculty: Agriculture

Roselle *(Hibiscus sabdariffa,L.)* is cultivated for the calyces, which are used for making roselle juice, a drink known to be high in vitamin C. The leaves are also used as a pot herb and some varieties are grown for their fibre. Roselle pods and seeds are by-products obtained after the calyces are removed from the fruits. The objective of the study was utilised the roselle by-products for small ruminant especially as sheep feed. Roselle by-products were obtained from farmers in Terengganu. In the first part of the study, chemical analysis was performed on the whole pods, seeds and empty pods. The roselle by-products were found to be high in protein, fat and fibre. The nutrient content of roselle by-products was higher than other agricultural by-products, such as sago waste, straw, cocoa pods, stalks and sugar cane bagasse.

In the second part of the study, *in situ* degradability of roselle empty pods and seeds was investigated. The result indicated that degradation of dry matter and organic matter of roselle seeds was higher than roselle empty pods,

significantly different ($P< 0.01$) in 48 hours, percentage of DM and OM of roselle seeds and empty pods were 36.38%, 28.36% and 23.01%, 17.66%, respectively; and also in 72 hours by 39.87%, 31% and 26.30%, 20.85%, respectively. Even though the seeds were more degradable than the empty pods, both were still low in degradability (< 50%). Degradability of roselle by-products can be improved by using chemical treatment, physical treatment or microbial treatment.

In the third part of the study, roselle by-products were treated with soaked alkali such as NaOH and $Ca(OH)_2$ at various levels (2%, 4% and 6%), and the nutrient contents analysed. It was found that the chemical composition of roselle treated with NaOH and $Ca(OH)_2$ decreased, except for ash.

In the fourth part of the study, feed intake, ADG and digestibility of untreated whole pod roselle and treated whole pod roselle with soaked NaOH 2% and $Ca(OH)_2$ 4% were used. It was found that total dry matter intake (TDMI) of untreated whole pods roselle and those treated with NaOH 2% and $Ca(OH)_2$ 4% were 25.22 ± 5.62%, 31.03 ± 4.67%, 36.11 ± 6.88% and total organic matter intake (TOMI) of untreated whole pods roselle and those treated with NaOH 2% and $Ca(OH)_2$ 4% were 22.64 ± 5.02%, 26.32 ± 3.95%, 30.53 ± 5.93%, respectively; and ADG (g/day) was 10.95 ± 2.56, 18.57 ± 2.88 and 15.95 ± 3.24, respectively. OM and DM digestibility of treated whole pods roselle was increased by 35.65% and 56.71% by 2% NaOH; and 14.04% and 14.43% by 4 % $Ca(OH)_2$. NDFD was increased by 23.18% and 71.18%, ADFD 24.74% and 88.10%, and also DE 26.12% and 27.47%, respectively.

Based on this study, it can be concluded that treated roselle by-products are potential alternative roughage for small ruminants, but these by-products cannot be used as a sole feed in the diet.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk Ijazah Master Sains

PENGGUNAAN HASIL SAMPINGAN ROSELLE (*HIBISCUS SABDARIFFA*, L.) SEBAGAI PEMAKANAN SERAT UNTUK BEBIRI

Oleh

TRI HESTI WAHYUNI

September 2000

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Roselle ditanam untuk mendapatkan kelopak buah dan digunakan untuk jus minuman yang mengandungi vitamin C yang tinggi. Daunnya pula boleh digunakan sebagai tanaman hias dan beberapa variati ditanam untuk menghasilkan serat. Kulit dan biji roselle adalah hasil sampingan buah roselle selepas diambil daripada kelopak buahnya. Kajian ini dijalankan bagi menggunakan hasil sampingan roselle untuk pemakanan ruminan kecil terutamanya bebiri. Hasil sampingan roselle diambil daripada peladang di Terengganu.

Analisis kimia telah dilakukan untuk mendapatkan kandungan proksimat. Hasil sampingan roselle didapati mengandungi protein, lemak dan serat yang tinggi berbanding dari kebanyakan hasil sampingan pertanian yang lain, seperti hasil sampingan sago, batang padi, kulit coklat, batang jagung dan ampas tebu. Dalam bahagian kedua kajian ini pula penghadaman secara *in situ* telah dilakukan

pada kulit dan biji roselle. Keputusan ujian tesebut mendapati penghadaman bahan organik (OM) dan bahan kering (DM) biji roselle lebih tinggi daripada kulit perbezaanya adalah berarti. ($P < 0.01$) pada penghadaman selama 48 jam masing - masing 36.38%, 28.36%; 23.01%, 17.66% dan 72 jam, 39.87%, 31%; 26.30%, 20.85%. Walaupun penghadaman biji lebih tinggi daripada kulit, penghadaman keduanya masih rendah (< 50%). Penghadaman hasil sampingan roselle dapat ditingkatkan dengan menggunakan uji kaji kimia, fizikal atau miokrob.

Dalam bahagian ketiga kajian ini, sisa hasil sampingan roselle telah diuji dengan menggunaka peratusan yang berbeza (2%, 4% dan 6%) NaOH dan begitu juga dengan $Ca(OH)_2$. Analisa kimia telah dibuat untuk mendapatkan kandungan proksimat. Didapati kandungan proksimat ujian hasil samping roselle dengan NaOH dan $Ca(OH)_2$, mengalami penurunan, kecuali abu.

Dalam bahagian keempat kajian ini, kadar pengambilan makanan dan penghadaman hasil sampingan roselle diuji dengan NaOH 2% dan $Ca(OH)_2$ 4% dan juga tidak diuji (sebagai kontrol). Keputusan ujian mendapati jumlah bahan kering dan jumlah bahan organik yang dimakan dari hasil sampingan roselle yang tidak diuji, yang diuji dengan NaOH 2% dan $Ca(OH)_2$ 4% masing - masing 25.22 ± 5.62%, 31.03 ± 4.67%, 36.11 ± 6.88% dan 22.64 ± 5.02%, 26.32 ± 3.95%, 30.53 ± 5.93%. Pertambahan berat badan per hari pula masing - masing 10.95 ±2.56, 18.57 ± 2.88 dan 15.95 ± 3.24. Penghadaman bahan organik dan bahan kering menunjukkan ujian hasil sampingan roselle dengan NaOH 2% dapat

ditingkatkan menjadi (35.65% dan 56.71%) dan $Ca(OH)_2$ 4% dapat ditingkatkan menjadi (14.04% dan 14.43%). Penghadaman NDF pula dapat ditingkatkan menjadi (23.18% dan 71.18%), ADF menjadi (24.74% dan 88.10%) dan juga tenaga penghadaman meningkat kepada (26.12% dan 27.47%).

Berdasarkan atas kajian ini, boleh disimpulkan bahawa hasil sampingan roselle merupakan salah satu sumber serat bagi pemakanan ternakan. Tetapi disebabkan oleh nilai penghadamannya yang rendah, maka pemakanan tersebut tidak boleh digunakan sebagai makanan tunggal didalam ransum.

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I certify that an Examination Committee met on 8th September 2000 to conduct the final examination of Tri Hesti Wahyuni on her Master thesis entitled "Utilisation of Roselle (*Hibiscus sabdariffa,* L.) By-products as Roughage Feed for Sheep" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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This thesis submitted to the senate of Universiti Putra Malaysia has been accepted as fulfilment of the requirement for the degree of Master of Science.

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Date: **14 DEC 2000**

DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations, which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

(Tri Hesti Wahyuni)
Date: 6 Nov. 2000

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LIST OF ABBREVIATIONS

DF	Acid Detergent Fibre
ADFD	Acid detergent Fibre Digestibility
ADG	Average Daily Gain
ADL	Acid Detergent Lignin
ADLD	Acid Detergent Lignin Digestibility
ANOVA	Analysis of Variance
ARC	Agricultural Research Council
dm	Decimetre
CF	Crude Fibre
CFD	Crude Fibre Digestibility
cm	Centimetre
CP	Crude Protein
CPD	Crude Protein Digestibility
° C	Celsius Degree
DE	Digestible Energy
DM	Dry Matter
DMD	Dry Matter Digestibility
DMI	Dry Matter Intake
EE	Ether Extract
EED	Ether Extract Digestibility
FPR	Fluid Passage Rate
PPR	Particle Passage Rate
g	Gram
GLM	General Linear Model
GE	Gross Energy
ha	Hectare
h	Hour (s)
in sacco	In Bag

in vitro	In Glass
in vivo	In Animal
Kg	Kilogram
ME	Metabolism Energy
ml	Millilitre
mm	Millimetre
NDF	Neutral Detergent Fibre
NRC	National Research Council
nm	Manometer
S.D.W	Sample Dry Weight
SAS	Statistical Analysis System
TADFI	Total Acid Detergent Fibre Intake
TADLI	Total Acid Detergent Lignin Intake
TCPI	Total Crude Protein Intake
TDMI	Total Dry Matter Intake
TNDFI	Total Neutral Detergent Intake
VFA	Volatile Fatty Acids

CHAPTER I

GENERAL INTRODUCTION

One factor limiting the development of animal production in tropical countries is the poor quality of forage. The low energy of forages is the main constraint, although protein supplementation is needed to obtain high performance of livestock production. From an economic point of view, using conventional feedstuff as energy or protein source is quite expensive to develop and increase animal production.

Another factor is land for forage production, which is always limited in developing tropical countries. Whether land can be spared for such use depends largely on population pressures and the need to produce staple food for humans. High human population densities are almost always associated with soil of high potential productivity, high rainfall and adequate water for irrigation systems where up to three crops a year can be cultivated. Livestock have been integrated into these systems and are usually multi-purposed in terms of providing draught power in addition to milk, meat, hides and dung for fuels and fertilisers. Such animals depend on crop residues and by-products of agro-industries for feed stuff.

The other factors, agricultural by-products from crop production, have numerous uses in both developing and developed countries. It is often stressed that these by-products should be degraded or burnt in the field in order to recycle organic matter and minerals, but the importance of this has not been defined. It

materials in excreta is more important in the small scale farming system, such as those in South East Asia, where land available for grazing is limited, and animals often compete with humans for feed resources. However, these by-products are generally characterised by low digestibility and hence low intake, low nitrogen content and unbalanced mineral content. The low digestibility of by-products is due to their high cell wall content of lignin, silica, and low supply of other essential minerals. As such, they do not meet the maintenance requirements of ruminants.

Malaysia still imports most of the concentrates used in animal rations except for small amounts available locally. The amount of animal feed required is expected to increase with the increasing rate of population growth and consequently increasing demands in livestock production. There is no natural pasture land in Malaysia other than small and scattered areas of mixed grasses and weeds on wasteland, road shoulders, fringes of rubber, coconut and oil palm estates and abandoned paddy lands (Mustaffa, 1987). Furthermore, the prospect for increasing areas sown to improve pastures is rather limited because of the high investment cost and slow return. Therefore, inadequate supply of good quality feed is one of the main constraints to ruminant production in Malaysia.

One of the alternatives to overcome this constraint is to utilise by-products from agricultural crops and agro-industry as animal feeds. It has been estimated that more than 5.0 million tonnes of agro-industrial by-products are available in Peninsular Malaysia (Mustaffa, 1987). Some of these are already commercially well utilised e.g. palm kernel cake (pkc) and rice bran. It is known that thousands

of tonnes of agro-industrial by-products are being burnt or dumped into rivers and ponds causing pollution to the environment. Effective utilisation of these by-products would serve two useful purposes, e.g. reducing the rate of pollution and providing new sources of feed stuffs for livestock.

Emphasis on food and diversification in agricultural results in a number of by-products being produced such as Roselle (*Hibiscus sabdariffa*,L.). Roselle pods and seeds are by-products obtained after the calyces are removed from the fruits. Roselle is one of the botanical species cultivated for its pleasant red colour calyxes which are used for making a common drink called karkade (Al-Wandawi *et al.*, 1984). It was reported by Earle *et al.* (1960) and also Watt and Breyer (1962) that roselle seed has high content of oil and protein. The total protein content of roselle seed is 25.20% (Al-Wandawi *et al.*, 1984) in comparison to 20.58% reported for mature okra seed (Karakoltsidid and Constantinides, 1975), which is considered to be potentially rich in protein with a high lysine level (Al-Wandawi, 1983). Currently the by-products of roselle are of no use and are sources of pollution. Malaysia produces more than 5400 tonnes of roselle pods yearly (Mardi, 1994).